GC Reservoir Property Prediction from Seismic Inversion Attributes Using MARS*

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[1]Rock Solid Images

General Statement

A common way to understand the relationship between seismic attributes and petrophysical properties is by the use of rock physics templates, or simply by cross-plotting well log-derived elastic attributes against a color-coded petrophysical property. Both methods graphically illustrate the relationship between the elastic and petrophysical domains, which can be used to estimate reservoir properties from seismic inversion attributes. The multi-attribute rotation scheme (MARS) is a methodology that uses a numerical solution to estimate a mathematical expression that reproduces the aforementioned phenomena. This methodology uses measured and/or rock physics-modeled well log information as an input to estimate a well log-derived transform between several elastic attributes and the target petrophysical properties. This transform is then applied to seismically-derived elastic attributes to predict the spatial distribution of petrophysical reservoir properties for reservoir characterization and delineation, and/or to estimate secondary variables in geostatistical workflows for static model generation and reserve estimation.

MARS estimates a new attribute *t* in the direction of maximum change of a target property in an n-dimensional Euclidean space formed by n-number of attributes. We search for the maximum correlation between the target property and all of the possible attributes that can be estimated via an axis rotation of the basis that forms the aforementioned space. Figure 1a shows a sketch illustrating an example for the particular case of two dimensions. This methodology evaluates the relationship between all possible elastic attribute spaces and a target petrophysical property using a similar correlation approach to the one used by in the extended elastic impedance methodology (Figure 1b).

Case Study: Onshore Colombia

For this case study, MARS was used to estimate water saturation, S_w, using a two-dimensional approach in a mud-rich turbidite gas reservoir, of Early and Middle Miocene age, located onshore Colombia. The global maximum correlation between the attribute *t* and S_w was found in the √(S-impedance) versus √(1⁄(Poisson’s ratio) attribute space at -19 degrees, with a correlation of -0.9625. Figures 2a and 2b show a comparison between the actual and predicted S_w curves upscaled to seismic resolution, in cross-plot domain and spatial domain, respectively, showing an excellent match. Finally, the resulting transform was applied to seismically-derived volumes of √(S-impedance) and √(1⁄(Poisson's ratio) to obtain a volume of S_w. A cross-section of the resultant S_w volume through well-A (used in the analysis) and well-B (a blind test) along with its S_w curves are shown in Figure 2c. In this figure it is possible to see a good match between the seismic and well-log derived S_w, not only at well-A, which was used in the MARS assessment, but also at well-B, which was used as a blind test location.

Case Study: South Falkland Basin

For this case study, MARS was used to estimate a lithology and fluid saturation volumes in both the Darwin East and West fault blocks. By applying the MARS methodology, customized transforms, using the elastic attributes and angles shown in Table 1, were found from the well log data to estimate reservoir properties from seismically derived elastic attributes. Figures 3a and 3b show a comparison between the actual and predicted water saturation (S_w) and volume of clay (V_{clay}) logs upscaled to seismic resolution, showing an excellent match. The resulting transform was applied to seismically-derived volumes of the elastic attributes shown in Table 1 to obtain volumes of S_w and V_{clay}. A cross-section of the resultant petrophysical volume through the calibration well together with its S_w and V_{clay} curves are shown in Figure 3c. In this figure it is possible to see a good match between the seismic and well-log derived petrophysical properties in Darwin East. Results suggest that the Darwin West prospect has similar properties to Darwin East in terms of reservoir quality and content. The resulting reservoir property volumes (S_w and V_{clay}) can further enhance the characterization of the heterogeneity of the reservoir, and can be applied during static model generation, reserve estimation, and to optimize the exploration, appraisal, and exploitation plan in the area.

Acknowledgement

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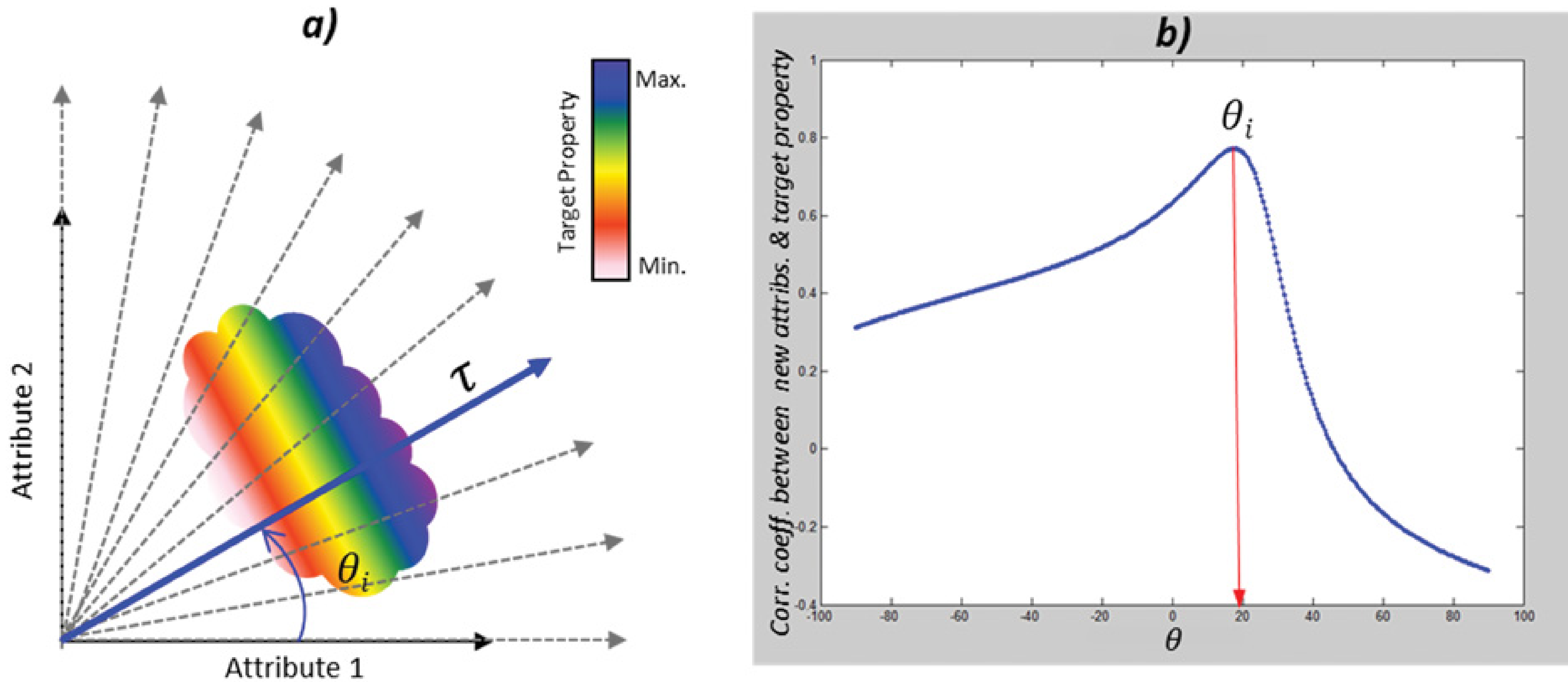

Figure 1. (a) Sketch of a cross-plot of two attributes color-coded by a target property. Dashed grey lines represent new attributes estimated via axis rotation, and the blue line represents the attribute that shows the maximum correlation coefficient with the target property. (b) Example of a cross-plot between the angles of rotation and the correlation coefficients calculated at each of these angles.

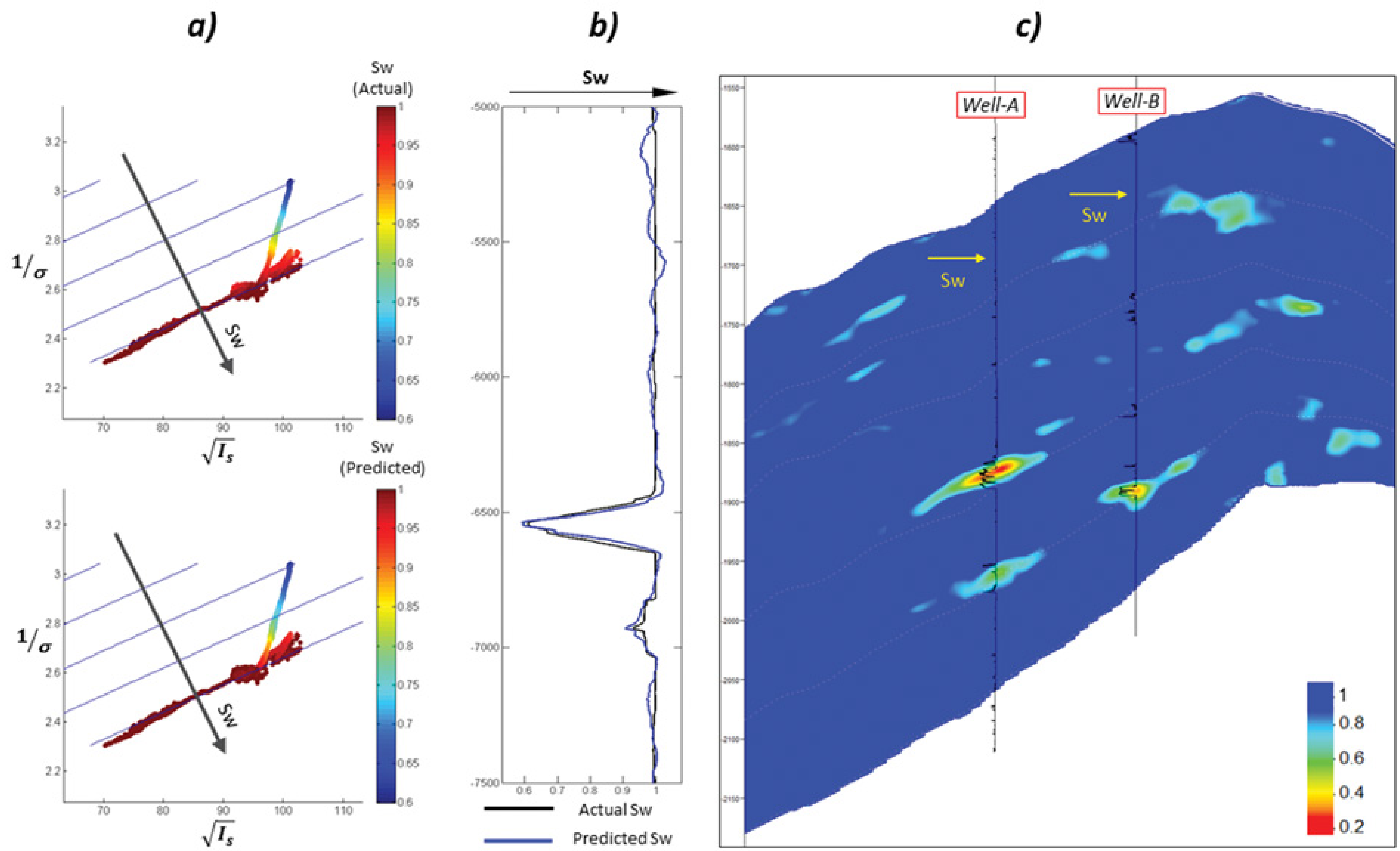

Figure 2. (a) Comparison of the upscaled actual and predicted S_w logs in the cross-plot space √(S-impedance) vs √(1⁄(Poisson's ratio)) (Well-A). (b) Comparison between the upscaled actual and predicted Sw logs (Well-A). (c) Cross section along the resultant S_w volume along Well-A and Well-B (blind well) together with its log of S_w. Notice the good match between the seismic and well-log derived S_w.

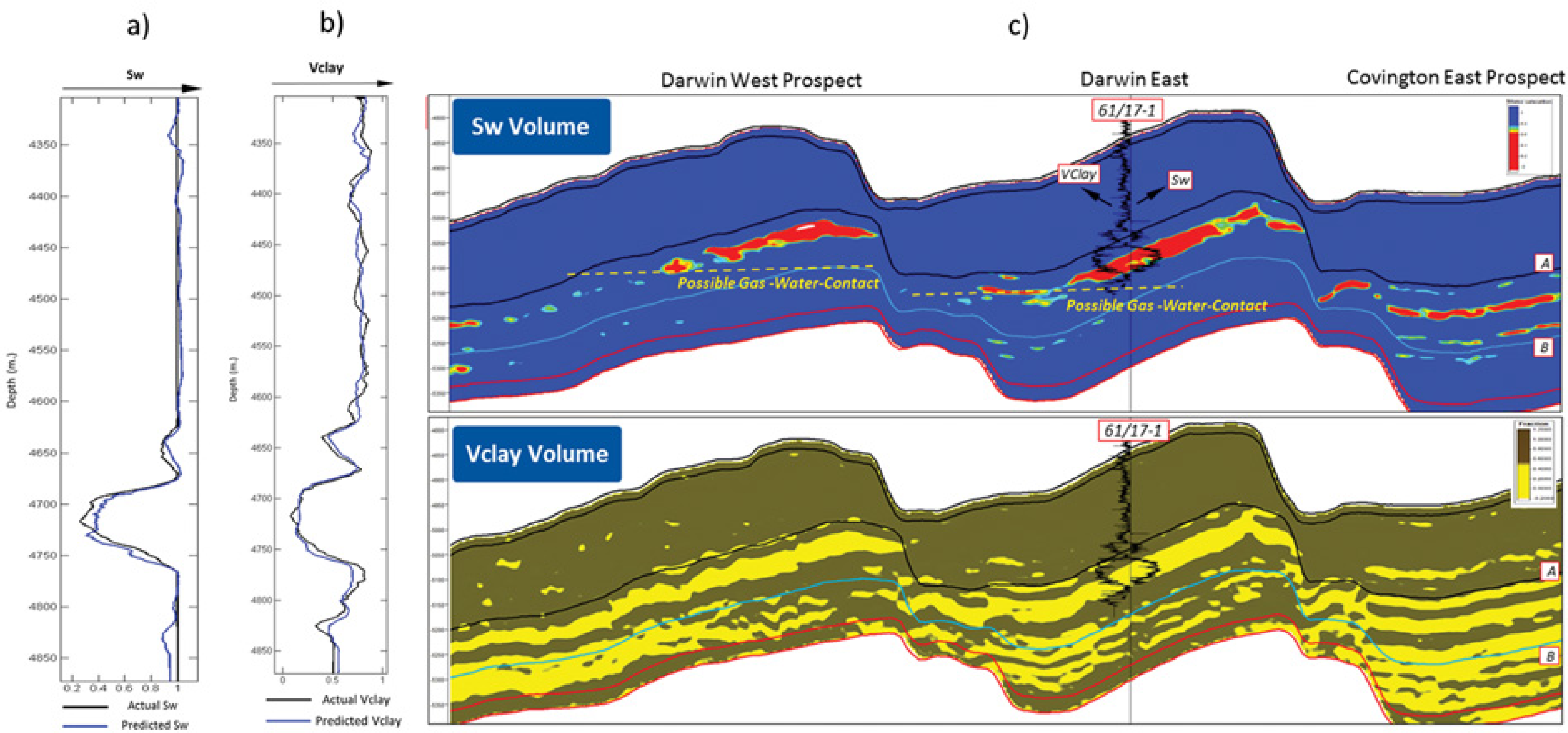

Figure 3. (a) Comparison between the actual and predicted S_w logs upscaled to seismic resolution. (b) Comparison between the actual and predicted V_{clay} logs, upscaled to seismic resolution. (c) Cross section along the resultant Sw volume along wells 61/17-1 together with the S_w and V_{clay} logs. Notice the good match between the seismic and well-log-derived S_w and V_{clay}.

Water Saturation		Volume of clay	
Attribute 1	1/Lambda Rho	Attribute 1	$(\text{Lambda Rho})^2$
Attribute 2	1/Kappa Rho	Attribute 2	$(\text{Poisson's ratio})^2$
Angle	-61°	Angle	12°

Table 1. Attributes and angle used in the MARS transform for the computation of S_w and V_{clay}.